the machine which would be liable to affect watches, etc., all the field being contained within the outer iron shell forming the yoke. Low speed in running is obtainable without increasing the size and weight of the machine, and the whole is cheap to construct, and combines features of mechanical strength and solidity with high electrical efficiency. Finally, the machine is remarkably free from any heating when running constantly and under full load. These machines are manufactured by the Wenstrom Northern Electric Company, of this city, of which Dr. J. B. De Lery is president; B. Blum, general manager, and B. J. Sturges, secretary and treasurer. This company intend to introduce their system for light and power in the Eastern, Middle, and Western States. The Wenstrom people have already installed during the past year several thousand lights in Baltimore and Annapolis.

THE NORTH AMERICAN MESOZOIC.[1]

IT has become customary upon such occasions as this for the speaker to select a theme from subjects which he is supposed to have specially studied; and I have therefore chosen for mine the mesozoic division of the geological record as it is exhibited on this continent. This theme is so comprehensive that I propose only to select from it certain topics which pertain to the distinguishing characteristics of the principal subdivisions of the mesozoic that have been recognized in different portions of North America; to their interdelimitation and to the delimitation of the division as a whole from the carboniferous system beneath, and the cenozoic above. I shall also make the discussion of these topics the opportunity of expressing certain views which I hold concerning them.

To bring these discussions within the time allotted me they must be confined to three general sections of the mesozoic formations, one of which occurs within each of three regions of the continent, namely, the Atlantic coast, the Pacific coast, and the interior regions. Proceeding upon this plan, let us first consider the general section which is to be observed in the Atlantic coast region.

The rocks which in this region are now generally regarded as of triassic age are found occupying limited isolated districts from Prince Edward Island on the north to the State of South Carolina on the south. If they extend further to the south, or south-westward, they are covered from view by later formations. They are found to rest unconformably upon various formations from the archæan to the carboniferous inclusive; except perhaps in Prince Edward Island, where they are reported as resting conformably, or nearly so, upon reputed Permian strata. Still, no intimate stratigraphical or paleontological connection between the Permian and the trias has been shown to exist there; and the hiatus between them is doubtless as great as it is farther southward, where the unconformity is so conspicuous.

In this latter portion of the region it is evident that the great uplift which involved the paleozoic rocks, including the reputed Permian, took place long before the deposition of the earliest of those triassic beds. These stratigraphical conditions indicate that the hiatus in the geological record between the latest of the carboniferous, and the earliest of the triassic deposits is equal to at least the earlier half of the triassic, as that period is represented in Europe.

The only known paleontological evidence which appears to bear upon this subject agrees with the stratigraphical indications just mentioned. That is, the results of investigations by Professor Newberry upon the fishes and plants of the strata in question, and of Professor Fontaine upon the plants of the same, indicate that they represent the later trias of Europe. But if triassic fishes had not survived to the present day; and if we knew more concerning the developmental stages in the vegetable kingdom from the later paleozoic to the later mesozoic inclusive, a good degree of uncertainty which is naturally felt upon this point would doubtless disappear.

Our knowledge of the land vertebrate fauna which existed at the time these deposits were formed is derived mainly from footprints; and it is therefore more than usually imperfect. The character of this evidence as indicating triassic, rather than earlier Jurassic age, seems to be far from unquestionable.

Very few invertebrate fossils have been found in the trias of the Atlantic coast region; and the few that have been discovered are of little or no value as indicating the age of the strata containing them.

As to the relation of these deposits with the carboniferous system, only stratigraphical evidence has thus far been obtained, and this shows only the bare fact that the former are of considerably later age than the latter. That is, no direct, or even approximately close, biological relationship between them has yet been discovered, the biological hiatus being apparently quite as great as the stratigraphical one. It may be mentioned here also that we have no evidence that the trias of the Atlantic coast was ever continuous, or that it was exactly contemporaneous, with the reputed trias of the interior region, which will be presently referred to.

Intermediate between the triassic beds and the undisputed cretaceous deposits of the Atlantic coast region there is a series of strata, evidently of littoral and estuary origin, but, at least in part, of doubtful age, to which the name of Potomac formation has been applied. These deposits reach at most only a few hundred feet in thickness, and although frequently covered from sight by later formations, they seem to have been originally continuous from New Jersey to the State of Mississippi. They have no known representative west of the Mississippi River, unless it shall be shown that they are represented by some sandy beds at the base of the Texas cretaceous section. These Potomac beds are usually found resting upon the archæan, and at only a few points are they found to rest directly upon the triassic rocks, when they are plainly uncomformable. They seem to be constantly present beneath the marine cretaceous strata just mentioned, and no representative of another formation has yet been observed between them.

Invertebrate fossils are exceedingly rare in the Potomac formation, and the few that have been found give no direct indication of its geological age. Professor Whitfield, however, has suggested that the Raritan clays, together with the Amboy clays, which by some geologists are included in the Potomac formation, but which are probably of later date, are of Jurassic age because of the similarity of his new lamellibranchiate genus *Ambonicardia* with certain European Jurassic shells.

Large collections of fossil plants have been obtained from the deposits here provisionally grouped together under the name of Potomac formation, at numerous and widely separated localities. These collections differ so greatly in character from one another that it seems necessary to infer that more than one flora is represented by them. Many years ago Dr. Tyson found some fossil plants in Maryland which he regarded as of Jurassic age, and which closely resemble certain forms that are found in the European Jura. Professor Ward, in reviewing the large flora which Professor Fontaine has published from the Potomac formation in Virginia, and having in mind also the Maryland plants just referred to, recognizes the Jurassic character of several of the species, according to the European standard, but he takes the rational ground that all obtainable evidence ought to be considered before reaching a final decision as to the true age of the deposits containing them.

Professor Newberry, who has made extensive studies of the plant remains of the Raritan and Amboy clays, finds among them none that give any indication of their Jurassic age. On the contrary, he finds that the flora of those clays as a whole indicates that they ought to be referred to an epoch not later than the middle cretaceous of Europe, nor probably earlier than the upper neocomian.

Professor Marsh has published some dinosaurian remains from apparently the same horizon in the Potomac formation that furnished the plants to Dr. Tyson and Professor Fontaine, which he has referred to the Jurassic.

Paleontological testimony being thus conflicting in its character, one naturally infers that more than one epoch is represented by the deposits that now bear the common name of Potomac formation; but I shall presently call your attention to some cases of commingling of earlier and later molluscan types in one and the same formation which are quite as remarkable as this apparent commingling of diverse plant and vertebrate types in the Potomac formation.

[1] Address before the Section of Geology and Geography of the American Association for the Advancement of Science, at Toronto, Ont., Aug. 29, 1889, by Charles A. White, vice-president of the section.

The marine upper cretaceous deposits of the Atlantic coast region which immediately overlie the Potomac formation are best developed in New Jersey; but there is good reason to believe that they were originally continuous with contemporaneous deposits through the whole length of the region from Long Island to the Gulf States and thence westward to, and far northward within, the interior region. This opinion is based upon specific identity of marine fossils discovered in the different regions.

The upper cretaceous of this region is overlain by eocene deposits, also marine, with little if any observable unconformity where they have been found in contact. I shall, however, presently mention facts which indicate that there is in the Atlantic and Gulf coast region a considerable hiatus between the cretaceous and eocene.

Briefly, then, the mesozoic of the Atlantic coast region consists of a probable representation of the upper trias of Europe, a possible one of the upper Jura, a probable slight one of the middle cretaceous, and a practically certain representation of a large part of the upper cretaceous, but with an hiatus between the latter and the eocene.

Although the cretaceous rocks are, or were originally, continuous between the Atlantic coast and interior regions by way of the Gulf States, the earlier mesozoic rocks of those regions respectively are so widely separated from each other that, as we go westward, we do not find any that can be confidently referred to either the trias or the Jura until we have passed the 100th or perhaps the 103d meridian.

As the latter meridian coincides with the western boundary of Texas, the foregoing statement implies that no triassic rocks exist within at least the greater part of the fully thirty thousand square miles in that State and in the Indian Territory, which some geologists have represented as being occupied only by rocks of that age. A personal examination of a large part of that region and of the fossils collected there has satisfied me that the sum of all the known evidence is in favor of the Permian age of the strata in question and against their triassic age. But these strata have an important paleontological relation with the mesozoic, to which I wish to call your attention for a few moments.

Upwards of fifty species of vertebrates, embracing reptiles, batrachians, and fishes, have been described from these rocks by Professor Cope, upon the evidence of which he referred them to the Permian of Europe, although, as he states, not one of the genera is common to both continents.

I have collected upward of thirty species of invertebrates from the same beds which furnished the vertebrates, representative examples of all the more important of which were obtained from one and the same stratum. Of these, fully one-half are common, characteristic coal-measure species. A part of the cephalopod species, however, possess such decided mesozoic characteristics that probably no special student of that class of fossil mollusca would hesitate to refer them to a formation not older than the trias, if they had been submitted to him without any information as to their true stratigraphical position.

It is a significant fact that if three special selections were made from the fossils of all kinds that have been obtained from this formation in Texas, one could be made, by the usual method of chronological classification practised by paleontologists, to prove its coal-measure age, another its Permian age, and still another its triassic age. It is admitted that the sagacity of an experienced paleontologist will often enable him upon limited evidence to become satisfied in his own mind as to the approximate age of a given formation; but it is only after all the obtainable paleontological and stratigraphical facts are carefully considered together that one is justified in expressing a definite opinion upon a subject of this kind. Such a summing up of all the evidence at present available seems to fully justify the reference of this Texan formation to the Permian of Europe.

My special object in presenting the foregoing facts is to call your attention to the important paleontological relation of the Texan Permian with the mesozoic, which is shown by the presence of ammonitic and ceratitic cephalopods among paleozoic types of mollusks. The discovery of such forms in such association in the Texan Permian, as well as in the Productus limestone of India, shows conclusively that certain mesozoic types began their existence long before the close of paleozoic time. Such forms in such association may be properly regarded as harbingers of an approaching, but not yet established, mesozoic era, because, in this case at least, the balance of paleontological evidence favors their reference to the paleozoic. Such facts as those which have been mentioned, as well as others presently to be referred to, indicate that upon the confines of epochs, periods, and ages of geological time there was always a commingling of types of then living forms which in their culmination were characteristic of each of those chronological divisions respectively. Furthermore, I shall call your attention to evidence that some of the types which especially characterized certain geological periods survived in full vigor through later periods. But let us return to a consideration of the mesozoic rocks.

Those rocks of the great interior region which have by common consent, but upon comparatively slight evidence, been referred to the trias, are found upturned against the flanks of the Rocky Mountain, and other ranges, and exposed to view in the valleys and cañons of the plateau province. They reach several thousand feet in thickness, and are so nearly uniform in color and lithological character over the whole of the great area within which they occur that they are often designated as the "red beds." They are found resting upon rocks of different age in different places, but in some districts they rest with apparent conformity upon a series of sandstone strata which are probably of Permian age.

This formation is apparently of non-marine origin, and, as a rule, it is quite barren of fossils. The few molluscan remains that have been obtained from it give no indication as to its age, and, in the light of present knowledge, the few plant and vertebrate remains obtained from it are far from satisfactory in this respect. Still, it is not my object to deny the triassic age of this formation, but only to call your attention to the fact that paleontological evidence upon this point is very meagre.

Because of the paucity of fossils both in this formation and in the reputed Permian upon which it rests in different districts, little is known of any paleontological relationship between them. There are, however, some indications of such relationship that deserve mention. The case of the commingling of mesozoic and paleozoic types in the Permian of Texas has already been stated. Another case in South Park, Colorado, may be mentioned, and the possible occurrence of still another in south-eastern Idaho may be suggested,

Important collections of plants and insect remains have been obtained from certain strata in South Park which are reported as immediately overlying rocks of unquestionable carboniferous age. The plants are regarded by Professor Ward as constituting the most characteristic Permian flora that has been found on this continent. The stratigraphical relation of these rocks is also suggestive of their Permian age; and yet Mr. Scudder referred the insects to the trias without qualification.

Some years ago Dr. Peale discovered in south-eastern Idaho an unique assemblage of fossils in strata which rest conformably upon the carboniferous, and evidently occupy a position beneath the triassic red beds, which occur in the same neighborhood. A part of the species belong to the *Ammonitidæ* and a part to the *Ceratitidæ;* and upon the evidence of these cephalopods Professor Hyatt referred the strata bearing them to the middle trias of Europe. When one remembers that cephalopod forms similar to those just referred to occur in India associated with a characteristic carboniferous fauna, he naturally inquires whether it is not possible that the Idaho strata ought to be referred to a period not later than the Permian.

Those Idaho strata and the South Park and Texan Permian all possess great interest as indicating an intimate relationship between the mesozoic and the carboniferous of the interior region; and if the record between the paleozoic and the mesozoic had not been so generally and so badly broken on this continent, we should doubtless now find many similar and more complete cases of the commingling of earlier and later types.

Some American field geologists have privately, if not publicly, expressed the opinion that the Permian ought to be assigned to the mesozoic, rather than to the paleozoic; but notwithstanding the paleontological relationship that has just been mentioned, such

a view is untenable when all the known facts are considered. It is at present sufficient to say that the great break between the mesozoic and paleozoic of North America occurred while yet paleozoic forms of life were far in excess of mesozoic forms; and that almost all the North American strata that have been recognized as of Permian age appear to have been the result of continuous sedimentation from the carboniferous. In short, all the hitherto recognized or reputed Permian of North America is far more intimately related, both paleontologically and stratigraphically, with the paleozoic than with the mesozoic. Therefore the lower delimitation of the North American mesozoic must coincide with the base of the lowermost discovered triassic strata.

A few hundred feet in thickness of strata, which have by common consent long been referred to the Jurassic, are found within a large part of the middle portion of the interior region, resting conformably upon the triassic strata which have already been noticed. Where these Jurassic strata have been fully studied, especially in Colorado and Wyoming, they are separable into an upper and a lower portion, the lower portion being of marine, and the upper of fresh-water origin. The invertebrate fossils of the upper portion are mostly of types that are now living, and are, therefore, of no value as indicating their geological age. Those of the lower portion are few, and the cephalopods only, or mainly, present such characters as to suggest their Jurassic age; and it was upon this slight evidence, together with the relative position of the strata, that their reference to the Jurassic was first made.

Professor Marsh's well-known publications of the remarkable dinosaurian faunas from both the upper and lower portions of the strata in question have left no reasonable doubt that they are really of Jurassic age. Professor Marsh refers all these strata to the upper Jurassic of Europe; and in connection with this statement I wish to call your attention to the fact that wherever they have been found in contact with the triassic strata already discussed, they are not only strictly conformable, but they seem to have been the result of continuous sedimentation. In fact, it is paleontology alone that suggests an hiatus between them. The field geologist finds no evidence of it.

The Jurassic rocks of the interior region disappear both to the northward and southward, their geographical range being apparently a little less than that of the underlying triassic beds. No equivalent of the former has been found in Canada, although the cretaceous Dakota group, which immediately overlies the Jurassic further southward, has been recognized there. It may be remarked also that where the Jurassic is not present beneath the cretaceous, the latter, especially in the eastern part of the region, is often found resting directly upon the older rocks, sometimes even upon the archæan. In Texas the Jurassic is also absent from beneath the marine formation, which is regarded as the representative of the Dakota group there, the latter resting directly but uncomformably upon the Comanche beds, to be presently noticed.

Omitting present consideration of the isolated masses of reputed Jurassic rocks in western Nevada and eastern California, this subdivision of the mesozoic seems to be represented in North America mainly by the slight accumulation of strata in the interior region which has just been noticed. We know little or nothing of the flora which existed when these strata were deposited; their invertebrate fossils are of little value in determining their geological age, and if it were not for their dinosaurian faunas their Jurassic age might well be questioned.

The section of the cretaceous formations which prevail in the central portion of the interior region, and to which I shall more particularly refer in following remarks, differs materially from a similar section in the southern portion, usually known as the Texas section. Meek and Hayden divided the cretaceous of the central portion of the region into the Dakota, Benton, Niobrara, Pierre, and Fox Hills groups, the first mentioned being the earliest, and the last one mentioned the latest. In Texas the cretaceous section is continued much beneath the equivalent of the Dakota group there. These lower Texan strata constitute the important marine formation now known as the Comanche beds, the molluscan fauna of which gives peculiar paleontological character to the Texas section. Above the Comanche beds there is a series of formations that are understood to respectively represent all the more northern formations which have just been mentioned.

After due consideration of all the known facts, some of which are of recent acquisition, there seems to be no room for reasonable doubt that the marine cretaceous deposits of the interior region which are later than the Dakota group are, as a whole, not only equivalent with the marine cretaceous deposits of the Atlantic and Gulf coast region, but that they were all originally continuous through the whole of that great geographical extent. These formations are too well known to need present characterization; and they are now known to constitute the most extensive and definite taxonomic horizon that has been recognized among the mesozoic formations of this continent. Furthermore, the marine molluscan fauna of these strata is of such a character as to leave little room for doubt that they represent homotaxially the Senonian, and perhaps a part of the Danian, of Europe. The difficulty, however, of accurately correlating the cretaceous formations of this continent with those of Europe is very great, as has, for example, lately been indicated by Professor Rœmer's reference of certain fossils of the Comanche beds to the upper Turonian. These beds lie wholly and unconformably beneath the horizon of the Dakota group, which is itself not probably newer than the Cenomanian.

Before proceeding to a consideration of the Laramie group, it is proper to say that the presence in British America of the Kootanie formation beneath the Dakota group, and that of the Comanche beds beneath the equivalent of the latter in Texas, shows that there is really an hiatus between the Dakota and the Jurassic in the interior region, although their conformity is so complete that it has never been detected by field observation. If a similar hiatus exists between the Jurassic and triassic in the same region, we have also no stratigraphical evidence of it.

The Laramie is in many respects one of the most remarkable of the North American formations. It is found occupying large portions of the interior region from the State of Nuevo Leon in Mexico to beyond 52° north latitude. It reaches a maximum thickness of nearly four thousand feet in Colorado, and more than that in British America. It is not only everywhere conformable upon the Fox Hills group, but wherever the junction between them has been seen, sedimentation from the older to the later formation appears to have been continuous.

In all its great geographical extent the Laramie group has never been found to contain any animal remains similar to those which inhabit the open sea only. A considerable proportion of its invertebrates are like those which are now denizens of brackish waters, and a still greater proportion are fresh-water forms. It is mainly upon this abrupt change from a marine to a brackish and fresh water character of the molluscan fossils, and not upon stratigraphical difference, that we rely to determine the lower limit of the Laramie formation.

The labors of Dr. G. M. Dawson and Mr. Whiteaves, and their associates in the Canadian Survey, have shown that conditions similar to those which gave character to the Laramie formation existed in a large part of the northern interior region long before the close of the Fox Hills epoch, and that they were probably continued into the Laramie epoch. But time will not permit me now to discuss this interesting question.

Besides the invertebrate fauna which has just been referred to, a few insect remains, a rich flora and a somewhat extensive and varied vertebrate fauna have been obtained from the Laramie formation. None of the molluscan remains, so far as I can judge, possess characters which any similar forms might not have possessed at any time from the middle cretaceous to the eocene inclusive; and a large part of them differ from living forms only as species.

Similar remarks may be properly made concerning the plant remains of the Laramie formation. Professor Ward has shown that of the one hundred and twelve genera of plants which have been discovered in the Laramie, thirty-eight of the genera and five of the species are common to the Dakota Group; eighty-five of the genera are living and twenty-seven are extinct. These extinct genera are all so nearly allied to living genera respectively that it is difficult to separate them. Furthermore, not less than three species from the upper strata of the Laramie have been identified with living species.

Mr. Scudder has referred the insect remains to the tertiary, but the vertebrate remains, especially those of mammals and land reptiles, are of more ancient types than those of the plants and invertebrates. Among the few Laramie mammals that have been discovered there is no indication as to the ancestry of that great mammalian fauna which characterized the immediately following Wasatch period. The reptiles are mainly dinosaurs of cretaceous types, but some of them seem to possess characters that suggest their Jurassic age.

Some paleontologists have long hesitated to give an opinion as to the true taxonomic position of the Laramie formation; but those who have studied the vertebrates only have usually referred it unqualifiedly to the cretaceous, apparently assuming that, containing dinosaurian remains, it could not be of later age. Field geologists, especially those who practically ignore paleontological evidence, also refer the Laramie to the cretaceous, because of its intimate stratigraphical relation to the marine cretaceous beneath it, and because in all the principal displacements, which the latter has suffered in the interior region, the Laramie was equally involved.

The formations which overlie the Laramie were, by common consent, long regarded as of tertiary age; but concerning the age of some of them, difference of opinion have since arisen. Between the Laramie and any overlying formation there is often, but not always, unconformity. In Utah, and apparently in the valley of the lower Yellowstone also, I have found the Laramie passing gradually up into purely fresh-water deposits without any stratigraphical break. In the former case I am sure, and in the latter case I believe with Professor Newberry, that the upper strata represent the lower part of the Wasatch group.

In Utah several of the fresh-water molluscan species, which are widely distributed in the Laramie, are found to have passed up into the Wasatch, thus confirming the stratigraphical evidence of the immediate succession of the Wasatch upon the Laramie. In southern Wyoming dinosaurian remains are found in some of the uppermost strata of the Laramie; and the lowermost Wasatch strata in the same region bear coryphodont and other placental mammalian remains; but remains of these two orders have never been found commingled. Still, in view of the facts just stated, it is not possible to doubt that those placental mammals lived contemporaneously with at least the last of the Laramie dinosaurs.

In north-western New Mexico and south-western Colorado, Professor Cope has found certain strata at the base of the Wasatch, and overlying the Laramie, to contain the remains of a peculiar vertebrate fauna whose distinguishing members are placental mammals which are quite different from those of the Wasatch. These strata he designates as the Puerco group, and he now refers them, together with the Laramie, to the cretaceous, because of certain characteristics which the Puerco mammalian and reptilian remains present; but he formerly regarded that group of strata as of Cenozoic age. These Puerco strata have the appearance of having been deposited simultaneously with those which elsewhere constitute the lower portion of the Wasatch group; and before their vertebrates were studied by Professor Cope their identity with the Wasatch was not questioned.

But we are not yet done with dinosaurs. Mr. George H. Eldridge has lately shown that in the vicinity of Denver, Col., there is a distinct formation, from 600 to 1200 feet in thickness resting unconformably upon the Laramie, which he has called the Arapahoe formation. Mr. Whitman Cross has also lately shown that still another formation in the same district, having a maximum thickness of fourteen hundred feet, rests unconformably upon both the Arapahoe and Laramie formations. To these strata he has given the name of Denver formation. The great aggregate thickness of these formations, together with their respective displacement with relation to the Laramie and to each other, shows that much time must have elapsed between the deposition of the uppermost Laramie strata in that district and the uppermost Denver strata.

Mr. Cross shows that a large part of the plant remains, which have been reported as coming from the Laramie in this district, really came from the Denver formation. Some of the fresh-water mollusca of the Denver strata I am not able to distinguish from Laramie species. But the most unexpected fact of all which these gentlemen have brought out is that both these formations above the Laramie contain dinosaurian remains in comparative abundance. The skull in some species is found to bear a pair of horns similar in posture and shape to those of the hollow-horned ruminants. Some of the bones also present characters which are suggestive of earlier mesozoic age; but in a general way, at least, these dinosaurs are similar to those of the Laramie.

The Laramie group does not reach its maximum thickness in the Denver district, and it is not known whether the latest Laramie strata are represented there. Both the Denver and Arapahoe formations are of limited extent, and it is quite probable that the latter, and perhaps the former, together represent the later portion of the Laramie period. But it is reasonable to infer that at least the later portion of the Denver formation was contemporaneous with the earlier fresh-water eocene strata of the Green River basin, notwithstanding the fact that the former bears dinosaurian remains.

The present state of our knowledge seems to justify us in regarding the marine cretaceous formations immediately beneath the Laramie as representing the Senonian of Europe, perhaps including even a part of the Danian. Now if we add to the American cretaceous the Laramie, Arapahoe, and Denver formations, we evidently extend the cretaceous in America much beyond its recognized latest limit in Europe.

But why, we may ask, should not those dinosaurs have survived from mezozoic, into tertiary time? Why should they not have continued their existence as long as physical conditions were favorable, and as long as they could compete in the struggle for existence with such mammalian faunas as that whose earliest known history is recorded in the earlier strata of the Wasatch formation?

Before summarizing the conditions of the mesozoic of the interior region and proceeding to a consideration of the Pacific coast section, I wish to refer to the relation of the Lamarie group with the marine tertiary of the Gulf and the Atlantic coasts.

For reasons presently to be mentioned, no direct stratigraphical proof of contemporaneity of our great fresh-water inland deposits with marine coast deposits is possible, and direct paleontological proof is not to be expected. I had long hoped, however, that because the Laramie group was in part of brackish water origin its continuity or contact with some marine coast deposit might be discovered. Such a discovery was first announced by Professor Cope, which I afterward confirmed, and showed that in the vicinity of Laredo, Texas, the Laramie group as a whole underlies with apparent conformity marine strata which contain an abundance of *Cardita planicosta* and other characteristic eocene fossils; but I was not able to detect the continuity of the Laramie with any sea-coast formation.

It was this discovered relation of the Laramie to the Gulf coast eocene that was referred to by the suggestion in a previous paragraph that there is really an important hiatus, although apparent conformity, between the cretaceous and the tertiary deposits of the Atlantic coast. The Gulf coast eocene just mentioned being regarded as equivalent with that of the Atlantic coast, and the uppermost marine cretaceous immediately beneath the Laramie, as equivalent with the uppermost marine cretaceous of the Atlantic coast, it follows that the hiatus referred to equals the whole of the Laramie. It may also be mentioned in passing, that, both upon stratigraphical and paleontological evidence, I regard both the northern lignitic of Hilgard in Mississippi and its equivalent in eastern Texas as equivalent with the upper, lignite-bearing, portion of the Laramie as it occurs in the valley of the Rio Grande.

Very briefly summarizing the mesozoic of the interior region, we find that its lower delimitation is greatly lacking in uniformity, the lowest member being sometimes the triassic, sometimes, but rarely, the Jurassic, and sometimes the cretaceous. The triassic apparently represents the upper trias of Europe, the Jurassic, the upper Jura, and most of the cretaceous, the upper part of that subdivision of the mesozoic. Above the marine cretaceous strata, inland sea and lacustrine deposits were continued into tertiary time, apparently without a break, either paleontological or stratigraphical.

Having to deal with extensive inland deposits alone when investigating the immediate relation of the mesozoic to the cenozoic in the interior region, we find that the most direct means of determining such relationship is wanting, because the continuity of the

marine paleontological record is broken at the base of the Laramie formation. Still, the opinion that we have a continuous record there from cretaceous into tertiary time is strongly supported by paleontological and stratigraphical evidence. But we come now to consider the mesozoic of the Pacific coast region, where we shall find proof of unbroken continuity of marine deposits from the upper cretaceous to the tertiary. Time will not permit me now to discuss the mesozoic of western British America, which Dr. G. M. Dawson, Mr. Whiteaves, and other Canadian geologists have done such excellent work upon, and I must therefore confine myself mainly to the California section.

The rocks of this portion of the Pacific coast region have been so greatly displaced since their deposition that their study is more difficult than that of the rocks of the interior region. Still, our knowledge of the upper part of the Pacific coast mesozoic is quite satisfactory. The oldest mesozoic strata of the California section which I shall specially refer to on this occasion were, by the California geologists, assigned to the lower cretaceous, under the name of the Shasta group. But these strata do not probably represent the very earliest part of the cretaceous period.

The exact relation of the Shasta group to the cretaceous formations above it has not yet been made clear; but Mr. Diller's investigations in northern California seem to indicate that the hiatus between them is not so marked as has been supposed. The geologists of the California Survey did not recognize any formation as belonging between the Shasta and Chico groups, but Dr. G. F. Becker has reported upon a series of strata in Mendocino county which he believes to be later than the Shasta, and earlier than the Chico. Upon examining the fossils which he collected from those strata, some of the species of which have also been found at Todos Santos Bay in Lower California, I concurred in his opinion, and suggested for those strata and their equivalents the name of Wallala group. Still, actual contact of this group with any other cretaceous strata has not yet been discovered, and its actual taxonomic position is not known.

From the base of the Chico group upward, the series of California strata which has been referred to the cretaceous is so well known that little if any difference of opinion exists as to essential facts concerning it, although a wide difference of opinion has arisen as to their significance and importance. This series, aggregating more than ten thousand feet in thickness, was divided into two groups by the California geologists; namely, the Chico below and the Téjon above, although they recognized the fact that there is no distinct break, either paleontological or stratigraphical, between them.

A considerable number of fossil invertebrates, among which are a species of baculites and several ammonitic forms, constitute such a decided mesozoic feature of the fauna of the lower portion of this Chico-Téjon series that the California geologists naturally and properly referred it to the cretaceous, The upper, or Téjon, portion contains a fauna that is so obviously cenozoic in character that several geologists, especially Heilprin and Conrad, have strenuously contended that it is of eocene age. A large proportion of these Téjon species are found to be so common in the Chico portion that if they were not there commingled with the cretaceous forms just referred to, the tertiary age of those lower strata would hardly be questioned. In short, there is in this stratigraphically unbroken Chico-Téjon series of California, a gradual transition of faunal characteristics from the cretaceous to the tertiary.

This transition was recognized by Mr. Gabb, and yet he referred the whole series to the cretaceous. His view was that, a portion of the series being assigned to the cretaceous, the remainder of it must follow, because the series can only be arbitrarily divided; and other geologists still entertain a similar opinion. By whatever name or names this great series of strata may be known, it is plain that it represents a continuous portion of geological time, extending from the later mesozoic to the earlier cenozoic age inclusive. Therefore the mesozoic series of strata in this portion of the Pacific coast region has really no definable upper limit.

It is true that by our present methods it is inconvenient to classify a series of strata like this, but the recognition of its true character is of far more importance than mere convenience of classification. Indeed this case constitutes one of the most instructive discoveries that has been made in the whole range of historical geology; and it should be understood as demonstrating that abrupt transitions from one epoch, period, or age to another have always been due to local or regional changes in physical conditions; or, in other words, to accidental circumstances.

Concerning the relation of the other members of the California section of the mesozoic to the Chico-Téjon series, or to each other, and the relation of the lowest of those formations to the Jurassic, our knowledge, as before mentioned, is imperfect.

The satisfactory correlation of a part of the cretaceous formations of the interior region with those of the Atlantic coast region has already been mentioned; but we have never been able to satisfactorily correlate any of the cretaceous formations of the Pacific coast region which have been mentioned, with any of those of the interior and Atlantic coast regions, even in cases of presumable contemporaneity. If such correlations are ever made, we must expect them through the labors of the Canadian geologists in the North-west. The whole fauna of each of the Pacific coast formations referred to seems to be different from that of any of the more eastern formations, the few cases in which specific identity has been recognized being of doubtful character. This inability to correlate formations in different and not far distant parts of our own continent, which were presumably contemporaneous in their origin, may well cause us to doubt the correlation of at least a part of the American formations with those of other parts of the world which various authors have confidently assumed.

It has already been shown that the lower limit of the North American mesozoic must coincide with the lowermost triassic strata in any given section, whether those strata are regarded as representing the earlier or the later trias; and that no strata hitherto recognized as Permian can be reasonably referred to the mesozoic. That is, the lower limit is defined by a great break in the geological record of this continent, constituting an hiatus, which began before the full completion of paleozoic time and continued until after the beginning of mesozoic time.

But we are quite unable to designate clearly the upper limit of the mesozoic in at least a large portion of this continent. It is true that in the Atlantic coast region the upper limit of the mesozoic is clearly marked where the marine eocene rests upon the uppermost of the cretaceous strata there, but that delimitation is produced by an hiatus. In portions of both the interior and Pacific coast regions, however, it is quite impossible to clearly designate the delimitating boundary between the mesozoic and cenozoic, because in at least a part of both regions no break in either the stratigraphical or paleontological record occurred until after cenozoic time was fully established.

In connection with the foregoing brief summary of the characteristics of the North American mesozoic, certain views have been expressed which I entertain in common with some, but not all, other geologists concerning the correlation of formations and the inter-relation of presumably contemporaneous fossil faunas and floras. The following propositions are offered as the basis of those views. A part of them, however, will not be questioned by any geologist, but these are given with the others for the sake of relevancy.

(1) In accordance with the principles of modern biology, we must conclude that, although it has not been demonstrated by actual discovery, there has been a continuous genetic succession of living organisms upon the earth ever since life began; that is, while numerous breaks in that succession have occurred, they have never been of universal, but only of local or regional extent, and they have been due to similarly restricted physical changes.

(2) The record of that succession of living organisms has been accomplished and preserved by the natural entombment of their fossilizable remains in aqueous sedimentary deposits. Subsequent physical changes have destroyed or rendered inaccessible a large part of the record, and all we know of that succession is derived from such of those remains as we have been fortunate enough to discover.

(3) The record of the succession of terrestrial life has been far less complete, and has suffered greater interruptions, than that of aqueous life, because the record of the former has been made under conditions which were irrelevant or inimical to that life, and

the entombment of its remains has always occurred under accidental conditions.

(4) The record of marine life is necessarily more complete than that of any other, because the seas have furnished continuous and more uniform conditions than either the land or fresh waters, and because the preservation of its remains was a natural consequence of the conditions under which that life existed. Therefore the record of marine life was less modified by other than evolutional changes of a cosmical character than that of the land and fresh waters, and it is consequently more trustworthy as an index of the progress of geological time.

(5) Breaks or interruptions in the succession of marine forms of life have been coincident with breaks of continuity, or with changes in the characters of the sediments by which their remains were entombed. These breaks in sedimentation, and in the succession of living organisms, are used by all geologists as indicating the delimiting boundaries of geological epochs, periods, and ages respectively, as well as of formations and systems. Their causes were independent of the existence of life, and their occurrence was accidental with reference to it.

It therefore follows that the recognizable time record in one part of the world is necessarily different in its divisions from that of any other part. For example, a period the close of which was marked by such interruptions as have been mentioned in one part of the world would be continued in other parts as long afterward as the occurrence of similar breaks there should be postponed. While such interruptions were occurring in one or more parts of the world, life and sedimentation were continuous and unaffected by them in others. This is plainly shown in the case of the Chico-Téjon series in California, because no inter-delimiting boundary occurs between its cretaceous and the tertiary portions, as has already been explained; while an evident hiatus exists between the uppermost known cretaceous and the lowermost known tertiary both in Europe and a large part of North America.

(6) While there has been progressive development in the order of succession of living organisms from lower forms in earlier, to higher forms in later geological time, the rate of progress of that development has not been uniform in all parts of the world for the same kinds of life. For example, the plant life of North America is now understood to have reached, in later mesozoic time, a higher stage of development with relation to animal life than it had in Europe; and the difference in grade among the now living indigenous faunas of the different continents respectively, indicates that a similar difference in the rate of development has also prevailed in different divisions of the animal kingdom.

(7) The various stages of progressive development of living organisms have been marked by the successive introduction and extinction of class, ordinal, family, and generic types; and yet certain of those types survived in some parts of the world during long epochs after they had become extinct in other parts. This proposition is supported by such facts as that of the survival into the Laramie, Arapahoe, and Denver epochs, of dinosaurian faunas which apparently show little if any indication of decadence or of approaching extinction; and also by the survival of highly organized representatives of mesozoic families and genera to the present time. Therefore it is not to be expected that we should find exactly the same association of faunal and floral types, or evidence of more than approximately the same grade of development of life in contemporaneous but widely separated formations. Therefore, also, the custom which has been adopted by some paleontologists of making the assumed absence of certain of those types a distinguishing element in the chronological diagnosis of formations is by no means to be commended, even if it were possible for us to discover remains of all the forms of life which then and there existed.

(8) Correlation of lake and inland sea deposits with those of open-sea origin, even within the same continental area, is necessarily a matter of uncertainty. This uncertainty is due to the great difference in the character of the faunas of those waters respectively, to the fact that constituent members of faunas of inland waters were not so diversely differentiated in the course of geological time as were those of marine waters; and also the inevitable want of geographical continuity of the two classes of deposits with each other, even in cases of actual contemporaneity. The only really trustworthy paleontological means of determining the equivalency or contemporaneity of deposits in such cases as these is the specific identification of such remains of land animals and plants as may have found entombment in then existing contiguous inland waters, on the one hand, and marine waters on the other. For reasons mentioned in proposition 6, the mere similarity of types, even of the more highly organized animals and plants, which may be discovered in different districts cannot be relied upon as indicating contemporaneity. Geographical continuity of strata being always wanting in such cases, the only aid to be expected from stratigraphy in determining equivalency of the formations must come through the discovery of the overlying or underlying position of the inland deposits with reference to marine deposits of known geological age.

It will be seen that these propositions involve serious questionings of the validity of certain methods and practices common among many of those geologists who devote themselves mainly or exclusively to paleontology. Such questionings afford scope for elaborate and varied discussions, but I shall close my present remarks with only a brief reference to the general subject of a proper recognition of a universal scheme of geological classification, which must of course have a biological basis.

The greater part of my own geological studies having been prosecuted from a biological standpoint, I am naturally not disposed to underestimate the value of paleontology as a branch of geological investigation, nor to encourage, even by incidental utterance, those who do. But I am sure no greater harm can be done to paleontological science than either to encourage, or to fail to oppose, the erroneous views which some of its votaries are shown by their own publications to entertain. For example, it is apparent to every one who is at all familiar with paleontological literature that many authors assume to designate with precision the geological age of any and all fossils submitted to them, as well as the taxonomic position of the strata from which they were obtained, without reference to stratigraphy, or to any related geological fact.

Those paleontologists who make this unwarranted application of their science to systematic geology, all use the scheme of classification that has been established for Europe, and use it as if it were of infallible application to all other parts of the world, and also as if it were already absolutely perfected for that continent. While I have no inclination to question the general accuracy of the European scheme of classification for that continent, I do not hesitate to express the opinion that it is not of infallible application to other parts of the world, except as to its larger divisions, and that even in this respect it will need modification. That is, I hold that investigations of the formations which are found upon any given continent or great division of the earth's surface ought to be prosecuted, first, with relation to one another, and second, with reference to their ultimate, not immediate, correlation with those of other continents or divisions.

It is true that the general consensus of geological thought and opinion has long been in favor of adopting the European scheme of classification in all, or nearly all, its details as applicable to all other parts of the world, and every considerate naturalist will treat such opinion with deference. But prevalence of opinion is by no means proof of its accuracy. None of the older naturalists present need be reminded of the great revolution in opinion that took place a little more than twenty years ago; and the older geologists will remember that the degree of displacement, the amount of consolidation, the crystallization and the lithological composition, of strata, were once accepted by all geologists as indices of the geological age of the formations which they composed. Remembering these incidents in the history of natural science, it does not seem unreasonable that present opinions should be frequently questioned, even those which are generally accepted.

I do not wish to be understood as condemning the scheme of classification now in use, nor even as recommending the present substitution of it by any other; but I insist that for universal application, it is plainly imperfect. A scheme of classification, as a working rule, is not only a convenience but a constant necessity; so constant, indeed, that I have not been able to present these remarks without its aid. But while the one which has been established for Europe ought by no means to be discarded, it ought to

be used tentatively in each of the great divisions of the earth, and with reference to the ultimate establishment of a universal scheme after all those divisions have been thoroughly investigated.

The time has come when North American geologists can, and ought to, hold a commanding position in this respect; and when we have elaborated a scheme of classification for the formations of our own continent, it will have equal claim to the favorable consideration of the geological world with any other.

NOTES AND NEWS.

AFTER a stoppage of two years, caused by a lack of funds, work was recently resumed on the double tunnel under the Hudson River between this city and the New Jersey side. Operations are restricted as yet to the Jersey City end of the north or up-river tunnel, which has been excavated to a distance of nearly two thousand feet from the shaft. The total length of the tunnel from shaft to shaft, when completed, will be 5,600 feet, to which must be added the length of the inclines or approaches leading to the surface, work upon which has not been begun. Work is carried on under an air-pressure of about thirty-four pounds to the square inch, and the heading progresses at the rate of twenty-five feet a week.

— Professor Elihu Thompson has perfected an invention by which the rails of street or steam railways may be welded together by electricity after being placed in position. A dynamo propels over the tracks an electric welding machine, which welds the rails into one continuous line after it passes over them. It is proposed to have at every one hundred feet a break, to allow for expansion. Any kind of rails can thus be welded.

— There has been patented in Germany a process by means of which sulphuric acid for manufacturing purposes can be safely transported. The inventor takes advantage of a property of certain salts — of which alkaline sulphates are representatives — by which they give up their water of crystallization when heated and take it up again when cool; and he does so by mixing the salts in an anhydrous condition with a calculated quantity of sulphuric acid. The whole mass becomes granular, or may be formed into cakes, and when heated the whole liquefies, and may be used as if it were sulphuric acid, for the presence of bisulphate of soda does no harm.

— Several reports received at the Hydrographic Office in Washington during the past month serve to illustrate the source of many doubtful or imaginary dangers to navigation that encumber the charts so long before their existence can be disproved. On July 14, in 43° 17′ north latitude, 57° 32′ west longitude, the captain of a Norwegian vessel sighted an immense dead whale which at a distance had the appearance of a rock. A number of sea-birds were about it. On July 22 the German steamship "National," while on a scientific exploring expedition, passed a dead whale under similar circumstances. On Aug. 2 the captain of a British steamship sighted a dead whale, about a hundred feet long, showing six feet out of water. It will readily be seen how easily such an obstruction might be mistaken for a shoal, and, if reported in a region where the depths are not too well known to admit of the possibility of such a thing, it might add one more doubtful danger to the many that have been reported.

— A nailless horseshoe which has been undergoing severe tests in England during the past two years, with satisfactory results, is described as follows: The shoe is attached by a steel band which passes below the coronet from one extremity of the heel to the other. This band is kept in position by a steel pillar which runs from the centre of the shoe up to the centre of the hoof. In addition there are three short studs, one in the centre of the shoe, and the others near the heel and on each side of it. It can be put on by any one who has once seen the process, which takes about half the time required with the cold-shoe system, which latter is an improvement as regards time on the ordinary process with nails. The nailless shoe diminishes or puts an end to cutting, and is particularly suited to brittle hoofs or hoofs with sand cracks. It costs as little, weighs as little, and lasts as long as the ordinary shoe; and, moreover, is not sucked off on heavy ground.

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CONTENTS:

ONE OF THE FEATURES of the meeting of The American Association at Toronto just closed was the growth of the societies devoted to special branches of science which meet each year at the same time and place as the association. The Botanical Club has been in successful operation for some years, as has also the Agricultural Society. This year there was held a meeting of the Geologic Society, and the formation of a chemical society was vigorously discussed. The Entomological Club is another of the groups into which congenial spirits unite, possibly to free themselves of the more cumbersome meetings of the sections of the association. Of the vice-presidents' addresses, we print this week those of vice-presidents R. S. Woodward and C. A. White. That by Professor H. S. Carhart, in the Physics Section, was a review of theories of electrical action. In the Chemical Section, Professor W. L. Dudley spoke of "The Nature of Amalgams." He gave a *résumé* of the most important work done in this interesting field, and a few results of his own. Appended to the address is a complete index to the literature, embracing over three hundred titles. In the Section of Mechanics and Engineering no address was delivered, and the work of the section was quickly over, few papers being presented. Vice-president G. L. Goodale's address before the Biologic Section was on protoplasm. The address of Vice-president Garrick Mallery, before the Anthropologists, treated of the "Israelite and Indian, a Parallel in Planes of Culture." This we hope to print in an early number. The remarks of Vice-president C. S. Hill before the Eco-